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ABSTRACT

This paper presents a two-phase model for conducting research on science teaching skills which incorporates results of studies already completed in teaching skill acquisition and effectiveness. The model is designed to aid the conceptualization, planning, and conduct of research. (SL)

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A MULTI-PHASE RESEARCH MODEL FOR EXAMINING THE ACQUISITION, USE, AND EFFECTIVENESS OF SCIENCE TEACHING SKILLS

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A MULTI-PHASE RESEARCH MODEL FOR EXAMINING THE ACQUISITION, USE, AND EFFECTIVENESS OF SCIENCE TEACHING SKILLS*

There are two common types of research studies conducted on teaching skills. One is concerned with acquiring teaching skills. These studies usually involve some variation in the training setting or training materials to determine how well teachers learn the skills of interest. An example would be a study of the ability of teachers to ask high level questions after studying different training programs.

The second type of study is concerned with the influence that teaching skills have on student outcomes. These effectiveness or validation studies usually involve teachers using skills in classrooms and then measuring what students learn. The skills are considered effective and valid when their use leads to desired student outcomes. An example of this type would be a study of the effects of different amounts of feedback on student achievement and attitudes.

Investigators often concentrate on either skill acquisition or skill effectiveness studies. By doing so they can determine either the influence of training programs on teaching skills or the influence of teaching skills on student outcomes. But there is a possibility of merging the research so that both types of studies are conducted in the same context. This merger will allow studies of the effects of variables such as the kind of training teachers receive or the level of skill teachers have on the degree to which student outcomes are influenced.

The purpose of this paper is to present a two-phase model of research on science teaching skills. The intent of the model is to help researchers see the relationships among studies of teaching skills, identify variables for

*The research model grew out of discussions with faculty and graduate students in the Department of Science Education. The authors wish to acknowledge the assistance these discussions provided in clarifying the model.

research on teaching skill acquisition and effectiveness, and pose questions for study that can lead to generalizable knowledge about training and teaching effectiveness.

The two-phase model is shown in Figure 1. The first phase deals with the acquisition of skills by teachers in a training setting. The second phase deals with the use of teaching skills in classrooms and the influence they have on students, i.e., it deals with skill effectiveness.

In the remainder of the paper the components of the model will be described and examples of research questions given. An example of a research situation will be presented to show how investigators can use the model to plan and conduct multi-phase studies.

Skill Acquisition Studies

In each phase of the research model there are three components that deal with antecedents, transactions, and outcomes. For the skill acquisition phase these components are:

teacher pre-assessment -- measures of ability, prior knowledge of the skill, aptitude, or any other teacher variable that may help in the analysis, prediction, or explanation of training results.

treatment conditions -- the amount and kind of training teachers receive can be systematically varied to see if skill acquisition is affected. Different kinds of training materials, variations in the amount of assistance during training, or alternatives in the context of the instruction (e.g., real or simulated classrooms) may be used in a study.

post-treatment assessment -- any suitable measure of the degree to which teachers acquire skills. Paper and pencil tests, teacher observation scale scores, or frequency counts of teacher behavior are among the kinds of measures used. Some measures of teacher outcomes may be made in classrooms (e.g., ability to provide verbal feedback) but others may not (e.g., the skill of preparing criterion-referenced tests).

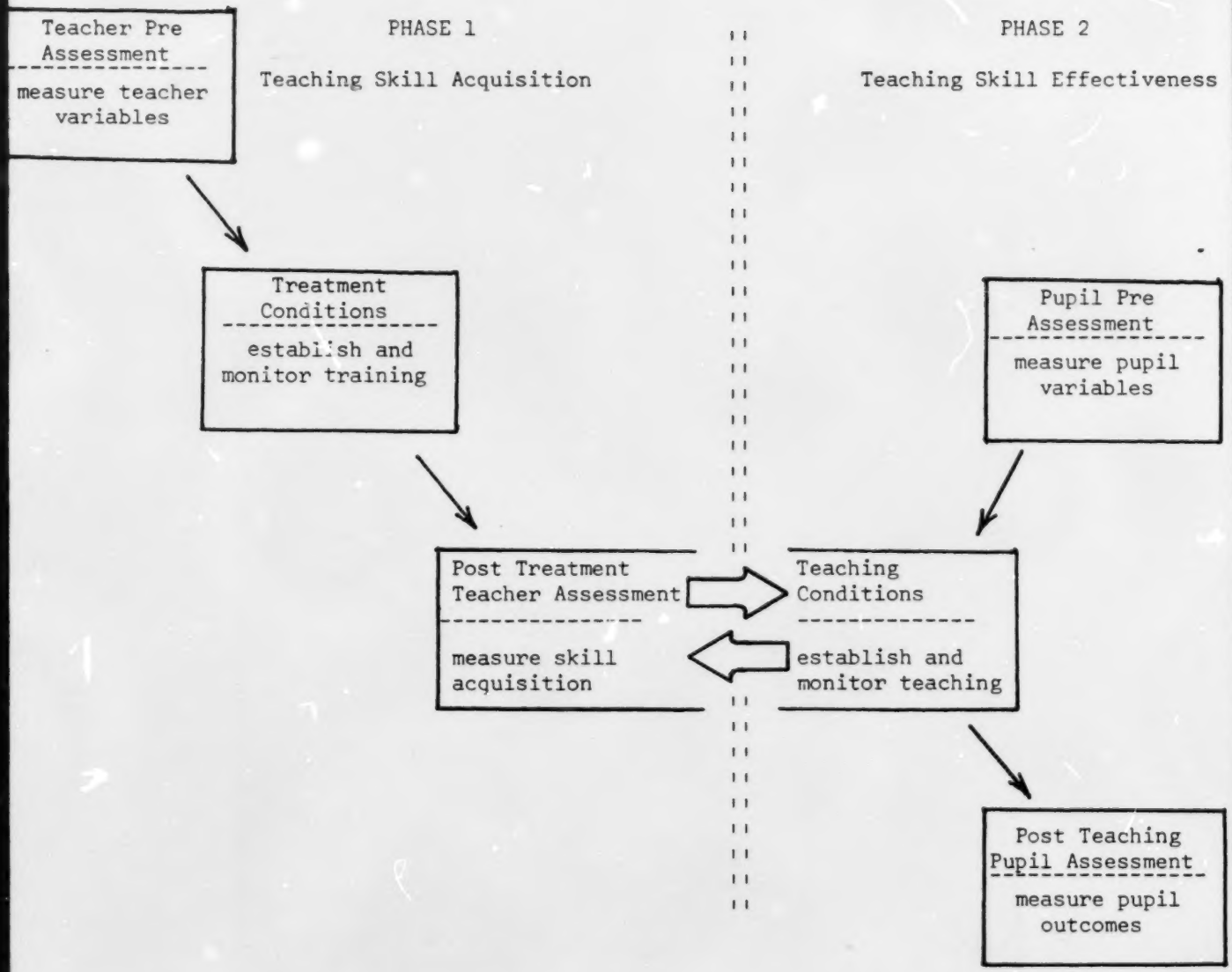

Figure 1. A multi-phase model for teaching skills research.

Skill acquisition studies are conducted by establishing treatment conditions and collecting suitable pre and post assessment data. By doing so, questions such as the following can be answered:

1. What pre-assessment variables are the best predictors of training success?
2. What variations in treatment conditions are most effective in influencing the acquisition of teaching skills?
3. Are the effects of treatment conditions consistent across the levels of teacher personalogical variables?

Skill acquisition studies can be conducted with both pre and post treatment measurements and variations in training. But other kinds of studies are possible. For example, the influence of variations in training can be studied with no pre measures on teachers if none are of particular interest or value. The model doesn't require multi-factor studies but allows for them when teacher variables in addition to treatment effects are of interest.

Multi-factor studies (i.e., studies involving both treatment variables and teacher personalogical measures) are important for several reasons. They provide the potential to identify teachers variables that influence skill acquisition. For example, the ability, personality, or aptitude of teachers may influence what they learn. In addition to considering the main effects of teacher personalogical variables, it may be determined that they interact with treatments to produce combinations of variables that lead to differential skill acquisition. For example, teachers who score high on an independent-dependent scale may especially profit from self-study training programs while the low scorers might learn best from highly guided programs. If combinations of personalogical measures and treatments that are more effective than others have been established in multi-factor studies, then teacher trainers have a basis for prescribing training conditions for teachers. Teachers with certain attributes are most likely to profit from particular training programs and can

be assigned accordingly. An alternative to the use of personalogical measures as factors in a study is to use them as covariates and thereby increase the power of the statistical analysis.

Variations in training need not always be a part of studies on the acquisition of teaching skills. If a standard of performance has been established, a study can be conducted with a single treatment (training condition) to determine if the standard has been achieved. Another type of study with no variation in training would be to examine the relationships that a set of pre measures on teachers has with the teachers' acquisition of skills.

Skill Effectiveness Studies

The second phase of the model is focused on the use of teaching skills with students. Either real classroom or microteaching situations may be used to examine what teachers do and the results that are produced with students. Note that the teacher behavior variables in the skill acquisition phase were considered as dependent variables. In skill effectiveness studies what teachers do is now the independent variable and what students achieve is the dependent variable.

The components associated with the skill effectiveness phase of the model in which teachers use skills they have learned include:

pupil pre-assessment -- measures of pupils such as prior knowledge, aptitude, level of motivation, IQ,or any other variable that may help in the analysis, prediction, or explanation of teaching effectiveness as measured by pupil outcomes. Pre measures on pupils can be used for the same purposes as was described for teacher pre measures.

teaching conditions -- measures of the level of skill used by teachers as they interact with pupils. The levels may be specified in experimental studies, be produced from natural variations in skill use among a group of teachers, or result from treatment conditions established during the skill acquisition phase.

post teaching pupil assessment -- any measures of pupils used as dependent variables in studies where teaching skills are applied. The particular measures depend on the teaching skills of interest and may range from scores on cognitive tests to frequency counts of pupil activities.

By selecting suitable pre- and post teaching assessment data and with appropriate variations and measures of teaching it is possible to answer questions such as:

1. Are there interactions of pupil variables and levels of teaching skill that result in effective and ineffective learning?
2. Are there relationships between the amount and kind of teaching skill used and the amount of pupil learning that results?
3. What levels of teaching skill use are compatible with students of different kinds?

Measurement of variables is emphasized in the pre and post assessment associated with both the acquisition and effectiveness phases of the model. But measurement is also important during the training and teaching components too. These are the points at which independent variables are manipulated during training or teaching. The investigator needs to document that these independent variables are used in the study in the way intended. For example, consider a study of the influence of videotaped feedback on learning inquiry teaching skills. Some teachers are to receive no feedback following their practice sessions and others are to view and systematically analyze their own teaching performance. It is important for the investigator to monitor both groups. For the control group the investigator wants to insure that they receive no feedback and for the videotape group it is essential to see that they do review and systematically analyze their teaching to insure the validity of the treatment conditions.

Multi-Phase Studies

The two sets of questions just posed relate to studies within either Phase 1 or Phase 2 of the research model. But a strength of the model is that

it bridges the gap between training research and teacher effectiveness research. When this happens, the teaching skills (dependent variables) from Phase 1 become the independent variables in Phase 2. This makes it possible to consider a new set of questions that link training variables with teaching effectiveness outcomes. Questions such as these can then be considered:

1. What types of treatment (teacher training) conditions influence student achievement?

2. What types of teacher training lead to the use of teaching skills in classrooms?

3. Are these interactions between teacher and pupil personalogical variables that lead to variations in student achievement?

Combinations of pre and post measures in either of the two phases of the model along with alternative teaching and training conditions can lead to variations of the questions posed above. The questions may come from investigators interested in improving their training program or in producing generalizable research findings.

Linking the two phases in the research model has the potential to stimulate investigations of not only best ways of learning certain skills but also examinations of the validity of teaching skills in effectiveness studies. A second advantage of linking the two areas of research is the stimulus each type of study can have on the other. For example, validating skills by establishing their effectiveness in empirical studies provides an impetus for incorporating the skills into training programs and determining how best to teach them.

The linkage of the two phases of the model that perhaps requires the most attention is the relationship between the post treatment assessment in Phase 1 and the teaching conditions in Phase 2. Under some conditions an investigator may <u>simultaneously</u> assess skill acquisition and determine the effects of the skills on pupils. The assessment may then serve the double

purpose of determining the effectiveness of training (Phase 1) and establishing the level of skill use during teaching (Phase 2).

Under other conditions an investigator may decide to bring all teachers to a selected level of skill acquisition at the close of Phase 1. The Phase 2 study might then be used to compare student outcomes under the guidance of these trained teachers to outcomes of students in classes of an equivalent group of untrained teachers. It would also be possible, after bringing all teachers to criterion on a skill, to assign levels of skill use. For example, all teachers may have been taught to use extended wait times following student responses, but for the purposes of the study they are assigned to use either 1 second, 5 second, or 10 second wait times with their pupils.

Using the Research Model

A proposed investigation is described in this section to illustrate how the model could be used in planning a study.

> A science educator plans to study question asking skills with a group of 75 elementary inservice science teachers. Three different question asking programs are commercially available for training teachers to use higher cognitive level questions with their classes. One training program emphasizes videotaped practice with peers, another audiotaped practice with pupils, and the third study of written materials about question asking. All teachers have at least two comparable classes available to use in the study.

This is an excellent setting for conducting research on skill acquisition and effectiveness. The results of the research can have significance to the local people involved and to a national audience. The local group can acquire teaching skills and determine what effects they have when used in classrooms. The national audience can learn about alternative ways of conducting training in an inservice setting and about the validity of a set of teaching skills.

How would the science educator use the model to help plan this research? The first step would be to select the questions to be answered and then decide on the measurements needed to answer them. The obvious questions are these:

1. Are the alternative training programs equally effective in teaching question asking skills?

2. To what degree do inservice teachers ask higher cognitive level questions in their classrooms after receiving training on them?

3. Does the use of higher cognitive level questions have a positive influence on the achievement of students?

The three questions above relate directly to the acquisition, use, and effectiveness of the teaching skills. But the model may stimulate additional questions. Are there any pre measures of teachers that could be taken here? The investigator may decide that teachers with high scores on a cognitive preference test are most likely to profit from study of higher cognitive level questions. This could lead to a fourth question.

4. Does the cognitive preference level of teachers influence their acquisition and use of higher cognitive level questions?

The investigator may also decide that the ability level of the students could interact with the use of higher order questions by teachers. It is possible that high ability students will achieve well no matter what kind of questions they receive and that middle and low ability students will especially profit from receiving practice in responding to questions at a variety of cognitive levels. This reasoning could lead to another question.

5. Are the effects of the use of higher level questions consistent across students of different ability levels?

The investigator has the option in this study of using the questioning skills of teachers that result from the three treatment conditions as the levels of questioning used during the teaching phase of the experiment. Referring back to the model, this means that the training outcomes of Phase 1 are also the teaching conditions for Phase 2. It also means that the

assessment of these teaching skills would serve both to measure the effectiveness of the three training programs and to determine the alternative teaching conditions that are in effect during the skill effectiveness study.

An alternative for the investigator is to insure that all of the inservice teachers have a minimal level of skill after the training phase of the study is completed. The teachers (all of whom can use higher cognitive level questions) are then arbitrarily assigned to use some specified level (e.g., 10%, 30%, or 50%) of high cognitive level questions with students.

The science educator must now operationally define the variables associated with each of the questions. There are also numerous decisions to be made about assignment of teachers to groups, scheduling of treatments, development or selection of classroom observation schedules, selecting classrooms of pupils and analyzing data. In short, many decisions about conducting the study remain. The model does not help an investigator plan these aspects of a study. Instead the model helps to identify variables and questions of interest. When this is done the investigator will require skills of planning and conducting investigations and analyzing data to successfully complete the study.

Discussion

It is important to keep in mind some of the things that this research model does and doesn't do. It doesn't dictate what kind of research designs to use, what teaching skills to select for study, or what analysis procedures to apply to the data collected.

But, the model does help a researcher identify variables and ask research questions. It should also help investigators link studies of skill acquisition and skill effectiveness. The linkage involves both designs and data. The designs are linked by carrying research subjects and teaching

skills through both the training and teaching phases. And the data are linked because of the relationship between the dependent variables in Phase 1 and the independent variable in Phase 2. The skills that teachers acquire during training are the same skills that are examined in classrooms to determine the influence the skills may have on pupil learning.

Other data linkages are possible by considering questions that relate, for example, teacher and pupil personalogical variables.

A systematic application of the model to teaching skills thought to be important in science teaching could expand our knowledge of how teachers acquire these skills and of the impact the skills have when used.